LM2661,LM2663,LM2664

Application Note 1142 LM2661/3/4 Evaluation Board



Literature Number: SNVA014B

LM2661/3/4 Evaluation Board

Introduction

The LM2661, LM2663, and LM2664 are part of a family of CMOS charge-pump voltage converters (*Table 2*). Each uses two small capacitors to achieve voltage inversion or voltage doubling without the cost, size, and EMI of inductor based converters. Each device has a shutdown feature and the LM2661 and LM2663 also provide the ability to run the clock oscillator from an external source. You may also slow the clock with an external capacitor on the LM2661 and LM2663. The small size and low profile of these circuits makes them attractive for cellular phones, laptop computers, Op Amp power supplies, interface power supplies, medical instruments, PDAs, and handheld instruments.

The LM2661 comes in SO-8 and MSOP-8 packages and requires only an extra diode to double the input voltage and provide up to 100mA of output current. It has a typical efficiency of 88% at 100mA output and a typical output resistance of 6.5Ω . This circuit typically draws only 500nA of supply current in shutdown mode and 120µA when operating. The internal oscillator frequency is 80kHz and the input voltage range is +2.5V to +5.5V (Note 1). The LM2661 is also capable of inverting an input voltage from +1.5V to +5.5V when used in a different configuration.

National Semiconductor Application Note 1142 Clinton Jensen July 2004



The LM2663 comes in a SO-8 package and inverts the input voltage to provide up to 200mA of output current. It has a typical efficiency of 86% at 200mA output and a typical output resistance of 3.5Ω . This circuit draws only 10µA of supply current in shutdown and 300µA when operating. The internal oscillator frequency is 150kHz and the input voltage range is +1.5V to +5.5V (Note 1). The LM2663 is also capable of doubling an input voltage from +2.5V to +5.5V when used in a different configuration.

The LM2664 comes in a SOT23-6 package and inverts the input voltage to provide up to 40mA of output current. It has a typical efficiency of 91% at 40mA output and a typical output resistance of 12 Ω . This circuit draws only 1µA of supply current in shutdown and 220µA when on. The oscillator frequency is 160kHz and the input voltage range is +1.8V to +5.5V (Note 1).

Note 1: Maximum input voltage for any input on this evaluation board is +5.5V.

Figure 1 contains the schematic for each circuit used.

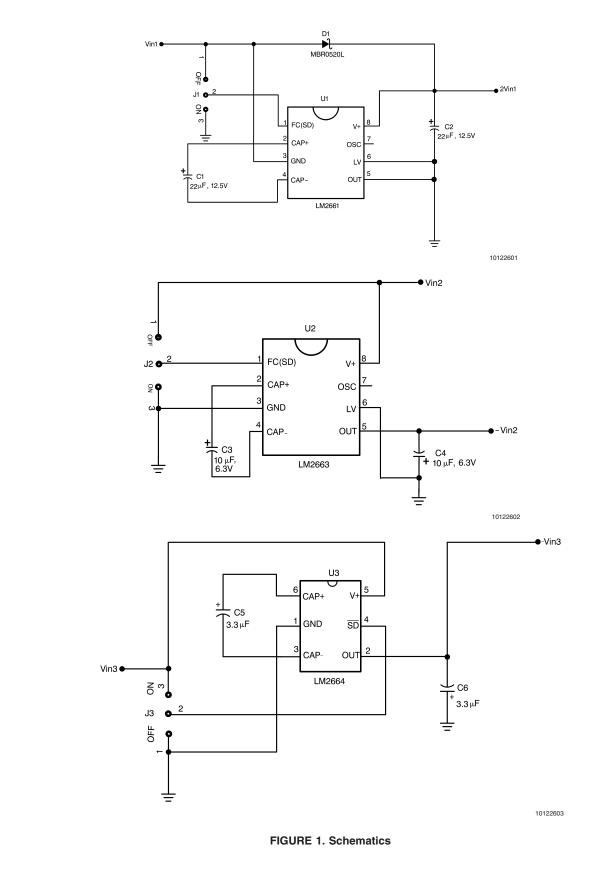
A silkscreen for the evaluation board is shown in Figure 2.

A listing of the products used is shown in *Table 1*.

A listing of the switched capacitor family is given in Table 2.

Introduction (Continued)





Discussion and Component Selection

On this evaluation board, the LM2661 is used in the doubling configuration. This configuration uses only two capacitors and one diode. There is a manual shutdown jumper designated as J1 included. The internal oscillator is used with a frequency of 80kHz. In doubling mode, the oscillator frequency can only be modified using an external capacitor and cannot be driven by an external clock. The Schottky diode D1 is needed only for start-up but should be able to handle the current required to charge the output capacitor (I=C*dV/ dt). An MBR0520LT1 20V, 0.5A diode is used on this board. Capacitor selection is very important. The capacitors chosen determine the output voltage ripple as well as the output resistance (Equation (1) and Equation (2)). From these equations it is easy to see how capacitor value and ESR help determine the output resistance and output voltage ripple. For this circuit Taiyo-Yuden type 22µF ceramic capacitors are used (Model EMK432BJ226MM). These capacitors are used because of their low ESR as well as stable temperature and frequency characteristics. Therefore they enhance the parts performance. Tantalum and ceramic capacitors and other values may be used as well to fit different performance, size, or cost requirements. Universal pads have been put on the evaluation board so that the capacitors can be replaced with those of a different size.

The LM2663 is configured as an inverter on this board. A manual shutdown is included and designated J2. The internal oscillator frequency of 150kHz is used. The capacitor selection here is important as well since the output resistance and voltage ripple equations are the same as they are for the LM2661 (*Equation (1)* and *Equation (2)*). This circuit runs at a higher frequency than the LM2661 so smaller capacitor values can be used. For this circuit Taiyo-Yuden

type 10 μ F ceramic capacitors are used (Model JMK316BJ106ML-T). Once again the low ESR and stable characteristics of these capacitors are the reasons they were chosen. Other types and sizes of capacitors may be used here as well for different performance, size, or cost requirements.

The **LM2664** is also used as an inverter on this board. A manual shutdown designated as J3 is included. The LM2664 does not have an adjustable frequency; it is fixed at 160kHz. This circuit has the same equations for output resistance and output voltage ripple as the previous two circuits and the capacitor selection is once again important (*Equation (1)* and *Equation (2)*). Taiyo Yuden multi-layer ceramic chip 3.3µF capacitors are used for this circuit (Model LMK316BJ335ML-T). These capacitors are chosen for their low ESR (measured $\approx 25 \text{ m}\Omega$) and small (1206) case size. They show the high performance of the LM2664 as well as the small size for the complete circuit. The output voltage ripple was measured to be less than 75mV peak to peak with a 40 mA load. Again other types and sizes of capacitors may be used for different performance and/or size requirements.

$$R_{OUT} \simeq 2 R_{SW} + \frac{2}{f_{OSC} X C_1} + 4 ESR_{C1} + ESR_{C2}$$

where R_{SW} is the sum of the ON resistance of the internal switches. R_{SW} is typically 1.4Ω for the LM2661, 0.9Ω for the LM2663, and 4Ω for the LM2664.

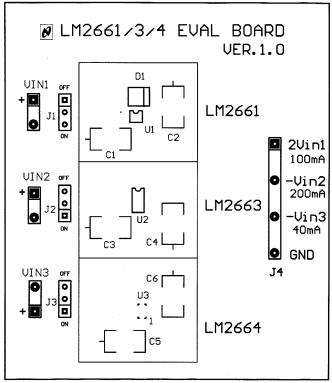
$$V_{\text{RIPPLE}} = \frac{I_{\text{L}}}{f_{\text{OSC}} \times C_2} + 2 \times I_{\text{L}} \times \text{ESR}_{\text{C2}}$$

(2)

(1)

Note 2: In these equations C_2 is always the output capacitor of the circuit.

Discussion and Component Selection (Continued)



10122606

FIGURE 2. Silkscreen

AN-1142

		TABLE 1. Components List		
Designator	Part Type	Manufacturer and Model #	Footprint	Description
U1	LM2661	National Semiconductor Corp.	MSOP-8	Charge-pump voltag converter
D1	Diode	Motorola (MBR0520LT1)	SOD123	20V, 0.5A Start-up diode
C1	22µF	Taiyo-Yuden (EMK432BJ226MM)	1206	Low ESR charge-pump capacitor, MLCC
C2	22µF	Taiyo-Yuden (EMK432BJ226MM)	1206	Low ESR charge-pump capacitor, MLCC
U2	LM2663	National Semiconductor Corp.	SO-8	Charge-pump voltag converter
C3	10µF	Taiyo-Yuden (JMK316BJ106ML-T)	1206	Low ESR charge-pump capacitor, MLCC
C4	10µF	Taiyo-Yuden (JMK316BJ106ML-T)	1206	Low ESR charge-pump capacitor, MLCC
U3	LM2664	National Semiconductor Corp.	SOT23-6	Charge-pump voltag
C5	3.3µF	Taiyo Yuden (LMK316BJ335ML-T)	1206	Low ESR charge-pump capacitor, MLCC
C6	3.3µF	Taiyo Yuden (LMK316BJ335ML-T)	1206	Low ESR charge-pump capacitor, MLCC
VIN1, VIN2, VIN3, J1, J2, J3, J4	Headers (36 posts per strip)	Amphenol (842-800-272-015) Newark stock # 87F6830	0.1" spacing	Connectors for input voltage, output voltage, and ON/OF jumpers (2/3 strip used, 22 posts used 19 actual pins used per board)
J1, J2, J3	Shunts	Circuit Assembly Corp. (CA-02SJC-B) Newark stock # 90F9279		Shunts for ON/OFF jumpers, shorts 2 pins, 3 shunts used per board

Contact Information

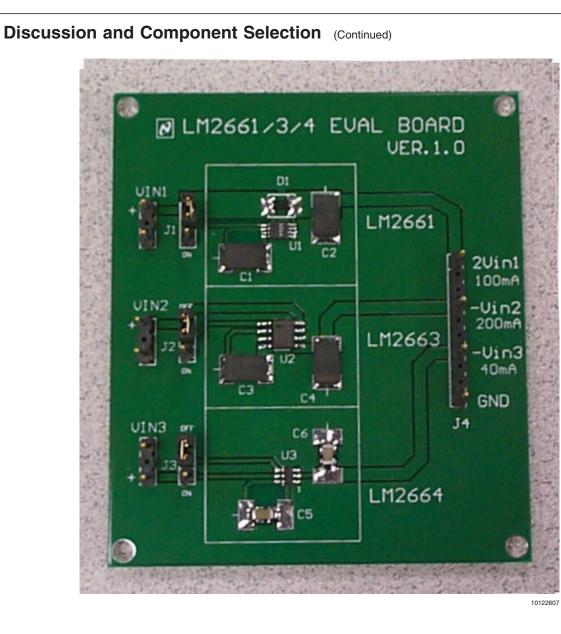
National Semiconductor Corp.	www.national.com	1-800-272-9959
Motorola	www.mot.com	1-800-521-6274
Taiyo Yuden	www.T-Yuden.com	1-800-348-2496
Newark	www.Newark.com	1-800-298-3133

www.national.com

AN-1142

AN-1142

				TABLE 2. Sv	TABLE 2. Switched Capacitor Family	tor Family				
Product	Function	R _o (ohms)	l _{оит} (mA)	V _{IN} range	f _{osc} kHz	І _а (µА)	Shutdown	Freq. Control	Freq. Sync	Package
LM2660	-V _{IN} or 2V _{IN}	6.5	100	1.5 to 5.5	10/80	120/400	No	Yes	Yes	MSOP-8, SO-8
LM2661	-V _{IN} or 2V _{IN}	6.5	100	1.5 to 5.5	80	1000	Yes	No	Yes	MSOP-8, SO-8
LM2662	-V _{IN} or 2V _{IN}	3.5	200	1.5 to 5.5	20/150	300/1300	No	Yes	Yes	SO-8
LM2663	-V _{IN} or 2V _{IN}	3.5	200	1.5 to 5.5	150	1300	Yes	No	Yes	SO-8
LM2664	-V _{IN}	12	40	1.8 to 5.5	160	220	Yes	No	No	SOT23-6
LM2665	2V _{IN}	12	40	1.8 to 5.5	160	550	Yes	No	No	SOT23-6
LM3350	3/2 V _{IN} or 2/3 V _{IN}	4.2/1.8	50	1.5 to 5.5	1600	3750	Yes	No	N	MSOP-8
LM3351	3/2 V _{IN} or 2/3 V _{IN}	4.2/1.8	50	1.5 to 5.5	400	1110	Yes	No	N	MSOP-8



AN-1142

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

Notes

- 1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
- 2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

BANNED SUBSTANCE COMPLIANCE

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.

AN-1142

National Semiconductor Americas Customer Support Center Email: new.feedback@nsc.com Tel: 1-800-272-9959

National Semiconductor Europe Customer Support Center Fax: +49 (0) 180-530 85 86 Email: europe.support@nsc.com Deutsch Tel: +49 (0) 69 9508 6208 English Tel: +44 (0) 870 24 0 2171 Français Tel: +33 (0) 1 41 91 8790

National Semiconductor Asia Pacific Customer Support Center Email: ap.support@nsc.com National Semiconductor Japan Customer Support Center Fax: 81-3-5639-7507 Email: ipn.feedback@nsc.com Tel: 81-3-5639-7560

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

www.national.com

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		
		u Hama Dawa	a O a Al a a m

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265 Copyright © 2011, Texas Instruments Incorporated